Preface

About the Text

This text supports an innovative three-semester calculus sequence redesigned to better serve the needs of students in STEM. It is one component of *Resequencing Calculus*, a National Science Foundation-supported project to better align the topics in the calculus sequence with their application in STEM courses and to improve student success rates. The text, like the project from which it arises, is designed to help students succeed, not only in calculus, but in all other STEM courses in which calculus is applied.

Topics are ordered so that material prerequisite for upper-level STEM courses is front-loaded into the first two semesters, Calculus 2 is an attractive jumping-off point for students in biology and chemistry, there is a natural progression of difficulty throughout the three-course sequence, and Calculus 3 includes a complete treatment of vector calculus—all while moving at a comfortable pace and without sacrificing rigor. This is accomplished through an early introduction to multivariate calculus, vectors, and sequences; a postponement of infinite series; and other minor changes designed to achieve appropriate pacing and balance across the sequence. As a consequence, Calculus 1 and 2 form a strong two-course sequence for students in the life sciences, economics, and chemistry, all of whom are likely to encounter multivariable models in later courses within their disciplines. Moreover, students successful in Calculus 2 are prepared not only for Calculus 3, but also differential equations, linear algebra, or calculus-based probability.

The topical ordering was developed in consultation with advisory boards consisting of educators in mathematics, biology, chemistry, physics, engineering, and economics at diverse institutions. The text, including the table of contents, has been refined through numerous revisions in response to feedback from the project assessment team, instructors at pilot institutions, accuracy checkers, manuscript reviewers, and the thousands of students who have used this text during its development.

About the Writing Style

The text is a reflection of the teaching style of the authors; we write the way we teach. We motivate new topics, develop new ideas by appealing to intuition, demonstrate techniques with an extensive set of examples, stress both conceptual understanding and computational ability, and connect new topics to those encountered earlier in a student's academic and real-life experience. We guide our students gently from confidence-building warm-up exercises to challenging, in-depth excursions and real-world applications.

About the Resequencing Calculus Project

The Resequencing Calculus project began with a pair of observations: A) Most students would benefit from seeing some multivariate calculus earlier in the curriculum, and B) Infinite series makes second-semester calculus more difficult than it should be. But changing how calculus is taught is a monumental task, impossible to consider without extensive support to develop and ultimately publish a text to support a revised sequence. This led to a pair of National Science Foundation (NSF) grants and a relationship with Wiley Publishing, a leader in the publication

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of innovative learning materials. The grants provided resources to assist with the development of the text and supporting materials, classroom testing and assessment at multiple institutions, consultation with diverse stakeholders, and extensive dissemination efforts. For more information about the Resequencing Calculus project, visit the project web site, www.resequencingcalculus.com.

About the Sequence of Topics

The ordering of topics is driven by the following key changes to the standard calculus sequence:

Functions of several variables are introduced in the second semester.

Students in the life sciences and chemistry would benefit from a two-semester sequence of calculus that includes an introduction to the calculus of functions of several variables, an observation underscored by the guidelines from multiple professional organizations and societies, including the American Chemical Society.

Vectors and matrices are introduced in the second semester.

Moving vectors earlier in the sequence allows for an early introduction to multivariate topics such as tangent planes, directional derivatives, and gradients. Moreover, treating vectors in the second semester increases the likelihood that students in engineering and physics will learn vectors in a mathematics classroom. Vectors and matrices are natural companion topics, and matrix algebra is frequently mentioned—both in discussions with STEM faculty and in the literature—as a topic needed by STEM disciplines in the first year. A formal treatment of matrices and determinants is also useful for later topics in calculus, such as the cross product, vector-valued functions, the Jacobian, the change of variables formula, and the total derivative.

Double integrals and their applications are introduced in the second semester.

Coverage of double integrals in the second semester serves as a natural extension of the theory and application of integration. After an exposure to double integrals in the second semester of calculus, a student with a command of both partial derivatives and double integrals has the essential tools to begin a calculus-based probability and statistics course the following semester, either concurrent with the third semester of calculus or instead of it. This is of particular benefit to students in statistics, data science, and actuarial science.

Series are moved from the second semester to the third semester.

This move provides a much-needed realignment of the difficulty levels of the second and third semesters of calculus. Most students who complete the traditional calculus sequence find the second semester to be the most difficult of the three, and the material on series is the primary culprit. By moving series to the third semester, the difficulty level of the second semester decreases and that of the third semester increases. This is as it should be. Few students who elect to take only the first two semesters of calculus have need for the complete treatment of series found in most second semester calculus courses. Those that do need the full treatment of series typically take three semesters of calculus anyway. By the third semester, they will have had more time to mature mathematically.

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Sequences and their limits are treated in the first semester.

Because of the increasing applicability of discrete models for STEM students, some of whom may take only one or two semesters of calculus, sequences are introduced in the first chapter as an example of a function. This early introduction allows for the consideration of limits of sequences in parallel with limits of functions of a real variable. Moreover, separating the introduction of sequences from infinite series eases the difficulty of learning infinite series.

Taylor polynomials are treated in the first semester.

Taylor polynomials are introduced as a natural extension of linearization. Taylor series and issues of convergence are considered formally later in the sequence.

Comparison with Traditional Texts

Semester	Calculus Resequenced for STEM	Traditional
1	Review of functions, including trigonometric, exponential, logarithmic, parametric, and polar Limits of functions and sequences Derivatives, including parametric Applications of derivatives, including polynomial approximations Integrals	Review of functions, including trigonometric, exponential, and logarithmic Limits of functions Derivatives Applications of derivatives, with heavy emphasis on graphing techniques Integrals
2	Techniques of integration Applications of integration Vectors and matrices Functions of several variables Double integrals Differential equations	Techniques of integration Applications of integration Differential equations Conic sections, parametric equations, and polar coordinates Sequences and series
3	Infinite series Vector-valued functions Surfaces, solids, and triple integrals Vector analysis	Vectors and vector functions Functions of several variables Multiple integrals Vector analysis

Supporting Materials

The student version of this text comes with the following materials, which will be available online:

Student solutions manual Includes solutions to all odd exercises

Chapter summaries A summary of key topics for each chapter

Chapter review exercises A set of additional exercises covering all of the sections in a chapter

Transfer modules A collection of online, self-guided learning modules designed to ease the transition for students who arrive with two semesters of traditionally sequenced calculus. (There is no need to assist students who arrive with only one semester of traditional calculus.)

Supplemental content A review of properties of functions, the formal definition of the limit, and a chapter on differential equations are available online.

Proof appendix Detailed, rigorous proofs of selected results not proved in the print version of the text

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Enhanced EBook

Calculus Resequenced for Students in STEM is available in an enhanced eBook format with four key advantages:

- The eBook includes selection of worked-example videos, and in-place solutions.
- The price is significantly lower than for the printed book.
- The eBook contains all material in the printed book plus web-only content in one easy-to-browse format.
- You can customize the eBook to include your choice of chapters.

Please contact your Wiley sales rep for more information about these options or check www.wiley.com/college/dwyer for available versions.

To the Student: About Calculus

Calculus is the mathematics of change. It provides a lens through which we explore diverse phenomena from motion to mass, from population growth to compound interest, from chemical reactions to reaction time. Wherever there is change, there is calculus. Calculus tackles the infinitely large, the infinitesimally small, and everything in between. Not surprisingly, a subject this powerful is required in nearly every STEM discipline.

Because of its wide-ranging applicability and the sheer brilliance of its arguments, calculus has been described as the crowning glory of the human intellect. It has a reputation for being a difficult subject, but if you are reading this, you can master it. This will require patience, practice, and, most importantly, the self-discipline to insist on understanding every concept you encounter *intuitively*. If you follow this program, you will be intrigued by what you discover and stunned by what you can do. We have written this text to help guide you on this journey.

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